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A FIELD TEST OF CANAIGRE-TANNED HEAVY LEATHER IN LOW QUARTER SHOES

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During World War II the dependence of the United States military forces on imported tanning extracts for making leather for military footwear focused attention on the importance of finding alternative sources within this country for such materials.

Over a period of many years the U.S. Department of Agriculture has conducted investigations on the possibility of using an extract of tannin from canaigre root; this grows wild in southwestern United States, but it may be domesticated.

The possibility of making an extract from canaigre root available for use in the tanning of military leather was brought to a head during the Korean War, when the Department of Agriculture launched a program to obtain a large enough quantity of these tubers so that planned application trials would be possible.

In view of the interest of the Department of Defense in primary sources of tanning materials, it was informally agreed that a production trial on military leather would be conducted as soon as the Department of Agriculture obtained a sufficient amount of tubers to permit the extraction of an adequate amount of tannin.

This report describes the planned application and the wear trial of a production lot of shoes which were made from leather tanned with canaigre root extract. This project was conducted jointly by the Eastern Utilization R & D Division, USDA, Philadelphia, and the Quartermaster R & E Command, Natick, Mass. The boots were tested by the Quartermaster Field Evaluation Agency, Fort Lee, Virginia.

The leather was manufactured by the International Shoe Co., St. Louis, which also produced the shoes for the test. Special thanks are extended to Messrs. R.H. Richards, C.H. Baker and the late G. Kevil of St. Louis, and to Messrs. William Vroman and John W. Green of the Frankford Tannery, Philadelphia.

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ABSTRACT

Dependence on foreign vegetable extracts was a matter of grave concern during World War II. The U.S. Department of Agriculture, after a survey of indigenous wild plants which could be used in their place, settled on canaigre, a tuber of the Southwest, for a major effort that included cultivation and manufacture of a commercially-acceptable extract. Under an agreement with the U.S. Army Quartermaster Research and Engineering Command, the extract was used in the tanning of sole leather on a pilot plant scale and a portion of the leather obtained in this test was used as components of low-quarter shoes for troops on garrison duty. The service characteristics of these shoes were studied over a period of 14 months.

Details of the tanning trial and the field test are described. Only minor, if any, differences between the shoe components made from canaigre and from standard leather were noted - except for the wear resistance of the outsole. The wear resistance of the outsoles was measured by comparing losses in outsole thickness before and after wear. By this method, oil-treated canaigre soles showed a 22% greater loss than oil-treated standard soles. This difference is sufficiently small to warrant the conclusion that the leather industry could produce canaigre-tanned leather as good as heavy leather tanned in the conventional manner, if it were to direct its efforts toward that goal. The field test, therefore, may be considered as an encouraging first step toward establishing canaigre as a domestic replacement material for critical and strategic tanning imports.

A FIELD TEST OF CANAIGRE-TANNED HEAVY LEATHER IN LOW QUARTER SHOES

Introduction

a. Statement of the problem

The problem of supplying the American leather industry with domestic tanning materials has already been stated in Report No. 11 of the Footwear and Leather Series (1) where efforts aimed at alleviating this situation were extensively reviewed. The above-mentioned report points the way toward a possible solution, by the evaluation of synthetic materials currently available for tanning, under a task program which the Munitions Board assigned to the Quartermaster Corps. Since then, further progress has been made and will be presented in a comprehensive report scheduled for release in 1960. A paper describing the production of heavy leather by tanning with aldehydes was presented at the annual meeting of the American Leather Chemists' Association in May 1958. (2)

State and Federal Agencies have long been interested in studying tannin-bearing indigenous plants as substitutes for imported tanning materials. One of these plants is canaigre (Rumex hymenosepalus Torr), a member of the dock family which grows in the southwestern part of the United States. For centuries its roots were known to the Indians and Mexicans as a source of tannin. Since the middle of the 19th century several attempts were made to develop canaigre as a commercial tanning material, but none of them was successful. Scientific work, conducted mainly by agricultural field stations, continued, however, resulting in numerous publications between the years 1878 and 1918. (3) Therefore, much was known about the botanical characteristics and especially the tannin content of canaigre when, just before World War II, a program was initiated for the development of domestic tanning materials in which the advantages of raising highly tanniferous plants as a regular farm crop was to be particularly stressed. (4) Canaigre offered advantages in this respect which seemed to recommend it for large-scale studies. These studies had already been going on for several years when the dependence of the American tanning industry on imports was forcibly demonstrated by wartime interference with

Allied shipping. Although the interest in canaigre was greatly stimulated during this period, problems connected with preparing a high-purity extract from the roots could not be solved before the emergency was over. However, it soon became apparent that, mainly because of the dwindling supply of blight-killed chestnut trees, the need for imported extracts by the leather industry was greater than before the war, without any prospect of its falling off. It was decided, therefore, to continue scientific work on the use of canaigre as a cooperative project of two agencies of the Department of Agriculture. Problems involved in growing and harvesting were to be studied by the Bureau of Plant Industry, Soils and Agricultural Engineering,* while the development of a suitable extract and the tanning experiments were to be the concern of the Eastern Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry.**

b. Progress reached before programming field test

The preparation of a tanning extract from canaigre tubers posed a unique problem because of the presence of a large amount of starch (25 to 40%) and of an excessive amount of nontannin, mostly sugars. Since the presence of starch prevents the use of temperatures higher than 48°C., an efficient extraction can be obtained only by fine grinding accompanied by mechanical separation of solid and liquor. Using this method, about 18 to 22 pounds of tannin may be obtained from 100 pounds of dry canaigre roots. (5) The purity of the extract may be increased by the fermentation of some of the sugars present. (6) Somewhat higher yields may be obtained by solvent-water extraction. (7,8) However, the economics of such a process have not been evaluated and the quality of the extract produced has not been established.

Extract prepared by water extraction and fermentation as described above was available in 1950 in sufficient quantities for a practical tanning and wear test. (9) After the usual beamhouse treatment at a tannery, 20 croupons were split along the backbone. The bends from the animal's right side remained at the tannery, where they were tanned by a commercial process. The bends from the left side were tanned at the laboratory, using a blend of 50% canaigre, 25% chestnut and 25% sulfited quebracho. The ratio of liquor to hide, the strength of

*Now: Crops Research Division of the Agricultural Research Service.

**Now: Eastern Utilization Research and Development Division of the Agricultural Research Service.

solutions, the countercurrent system of tannage used and the time of tannage (6 weeks) were similar to standard practice; the liquors were "mellowed" before use by tanning in them a number of blends which were discarded. All leathers were finished at the tannery under the same conditions. The laboratory-tanned leather was of good appearance and color, was not cracky, and was at least equal in every respect to the control leathers.

The wear test was conducted by about 70 mail carriers in the Philadelphia area. One shoe from each pair contained a canaigre sole and the other shoe contained a control sole cut from a corresponding position on the opposite side of the same hide. Wear was followed by weekly inspections and when a hole appeared in either shoe, the pair was resoled, reversing the canaigre and control soles. At the end of the test, a careful evaluation of the wear data indicated that the soles tanned with a canaigre blend were slightly, although not significantly, superior to the control soles.(9)

PART I: PLANNING AND PREPARING FOR FIELD TEST

1. Manufacture of canaigre leather

While the wear test described above was in progress, the Eastern Regional Laboratory of the Department of Agriculture continued to manufacture in its pilot plant canaigre extract from the root material harvested by a number of Experiment Stations. By 1955 about 10 tons of extract had been obtained in this manner. Details of the pilot plant extraction process are reported elsewhere. (10) Encouraged by the success of the wearing trial with the Philadelphia mailmen, the Department of Agriculture approached the Quartermaster Corps with the suggestion of organizing a test by the Quartermaster Field Evaluation Agency which would definitely establish the merits of canaigre-tanned leather. The QM Research and Engineering Command agreed to start a wear test similar to that conducted with a domestic syntan several years earlier (11) provided sufficient leather of suitable quality could be furnished.

It was also decided not to employ a blend (as had been done in the wear test with the mailmen) but only canaigre extract, just as the syntan had been used by itself in the earlier test. The exclusive use of canaigre would demonstrate its feasibility as a substitute not only for imported quebracho but also for domestic chestnut. An agreement to this effect was reached under the guidance of Dr. S. J. Kennedy, Chief, Textile, Clothing and Footwear Division of the QM Research and Engineering Command in Natick, Mass.

To evaluate a new tanning material under the counter-current procedure of normal tannery practice would have required at least 50 tons of extract. Since only 10 tons were available, it was necessary to adopt certain departures. The tanning facilities selected allowed the tannage of 150 hides in two lots of equal size. These were heavy native steers, May/June take off: average weight 74.5 pounds. The hides were given the normal beamhouse preparation.

One-third of the available powdered extract was liquefied to yield liquid extract A, and later the remainder was liquefied to give liquid extract B. Analysis of the powdered extract and of the two liquid extracts is presented in Table I.

TABLE I: ANALYSIS OF CANAIGRE EXTRACTS (in %)

	Total Solids	Soluble Solids	Insolubles	Non-Tannin	Tannin	Purity
Powdered extract	95.9	94.3	1.6	42.6	51.7	54.8
Liquid Extract A	31.3	30.5	0.8	13.9	16.6	54.4
Liquid Extract B	34.3	33.4	1.0	15.2	18.2	54.5

To start the tannage, a weak liquor of 7° Barkometer was made from extract A and the first lot of hides was hung (Vat 1). After rocking for one hour, 10 inches of liquor were sewered, the vat was refilled with 9° Barkometer liquor and left to rock overnight. The sap liquor from this vat was mixed with sufficient 9° Barkometer liquor to prepare the tail liquor for the second lot of hides (Vat 2). On succeeding days the liquor in Vat 1 was strengthened with the required amount of liquor prepared from the liquid extract. The liquor in Vat 2 was strengthened with the sap liquor from Vat 1, except for the last few days, when fresh liquor was used. During the course of the tannage, which lasted about 4 weeks (from 12 October to 9 November 1955), all of extract A and a portion of extract B were used.

The rate of penetration was followed by taking cuts from the edge of the backbone of different bends. These estimates - available for only the first 17 to 20 days - are shown in Table II. Full penetration was noted after 4 weeks; then the bends were removed from the vats. During tannage the pH of the liquor was adjusted with lactic acid to about 5.5, and the pH of the liquid extract to 3.0. After tannage, the leather was extracted with extract B (part of which was sulfited) and put into a tempering layer made from extract B and spent tanning liquor. Typical

TABLE II: PENETRATION OF CANAIGRE LIQUOR DURING TANNAGE

Days	Thickness of Cut (mm)	Penetration Grain (mm)	Penetration Flesh (mm)	Penetration Both Sides (%)
		#1 Vat (Fresh Liquor)		
3	7	0.5	0.5	15
6	8	1.5	1.5	40
8	6	1.5	1.5	50
10	9	2.0	2.5	44
13	8	2.5	1.5	50
15	7	4.0	1.0	70
20	11	3.0	5.5	70
		#2 Vat (Liquor Made from Sap of Vat #1)		
3	8	0.5	0.5	13
5	8	1.0	1.0	26
7	6	1.0	0.5	20
10	8	2.5	1.5	50
12	9	4.0	3.0	80*
17	7.5	2.5	2.0	60

*Discrepancy in rate of penetration is probably due to method of cutting sample from different portions of different bends.

results obtained in analyzing the various liquors are presented in Table III. The leather was bleached, oiled and finished by the same procedure used in the regular production of the factory which conducted the tannage.

TABLE III: TYPICAL ANALYSES OF TANNING LIQUORS (%)

	Barkometer	Total Solids	Soluble Solids	Insolubles	Non-Tannin	Tannin	Purity
1st Vat Tail Fresh	5.5	1.5	1.4	0.07	0.6	0.8	54.3
1st Vat Tail Sap	5.5	1.0	0.9	0.06	0.6	0.4	38.3
2nd Vat Tail Fresh	4.5	1.1	1.1	0.02	0.7	0.4	38.5
2nd Vat Tail Sap	4.0	1.0	0.9	0.08	0.7	0.2	18.0
1st Layer (Head)	66.5	15.8	15.2	0.6	7.3	8.0	52.2
2nd Layer (Head)	65.5	15.6	14.7	0.9	7.1	7.6	51.8
Tempering Liquor #1	60.5	14.4	14.0	0.4	7.4	6.6	47.2
Tempering Liquor #2	65.0	14.9	14.2	0.6	7.3	6.9	48.5

The resulting leather was closely examined before being processed further for shoe parts. Its color was on the dark side and very uneven. It was firmer than standard sole leather, but its lower density* and fiber structure, especially in the bend area, pointed to a somewhat slack tannage.

It will be noted that in this test there were two radical departures from procedures normally used in the tanning of sole leather. The first was the use of a single tanning material instead of a blend; and the second was the use of astringent rather than "mellow" liquors, in the early stages of tanning. These would create a tendency toward slack tannage and cracky leather. These factors must be kept in mind when the results are evaluated.

*.98 and .96 in bends and bellies respectively. Test was by courtesy of Leas and McVitty, Inc., Salem, Va.

It should also be pointed out that since the inception of this test additional work by the Field Crops Research Division has resulted in the development of improved strains of canaigre tubers having higher tannin contents and greater purity of extract. (12) The use of such improved strains of tubers together with the available improvements in methods of extraction should result in a better quality extract than was available for this test.

2. Physical and chemical properties of canaigre leather

For the physical and chemical analysis the leather was sampled by cutting out test pieces specified in the Methods Book of the American Leather Chemists' Association.* The results of the chemical analysis are shown in Table IV. The requirements of Federal Specification KK-L-165 for factory sole leather (Type I) were met without exception. However, the second batch of bends showed a degree of tannage only 0.2 above the minimum.

The physical tests were less favorable to the leather. It did not meet Federal Specification requirements in crackiness nor, except for the bellies, in pipiness. Compressibility, on the other hand, was well within the limits set by the specification.**

3. Manufacture of shoes for field test

Despite strong indications of what may be called a "touchy grain," no particular difficulties were encountered in the subsequent manufacture of 1600 pairs of shoes. These were low-quarter dress shoes (i.e., black oxfords, conforming to MIL-S-13192A) and were cross-mated for the field test with standard shoes of identical construction. However, the canaigre-tanned insoles were not chrome retanned, in contrast to the insoles of the cross-mated standard shoe. The oil treatment required by the Specification was applied to the outsoles of all standard shoes but to only one-half the number of the canaigre-tanned outsoles. It was the considered opinion of the superintendent of the factory where these shoes were made that the number of hard outsoles was about the same as resulted from making the same number of shoes from standard stock. The canaigre insoles were so much better for inseaming than standard insoles that not a single one was damaged by the process.

*See Provisional Method J15 in Methods Book, 1954.
**Tests were made through the courtesy of Armour Leather Company, Chicago.

TABLE IV: CHEMICAL ANALYSIS OF CANAIGRE-TANNED SOLE LEATHER* (DRY BASIS)

(in %)

	Bends		Shoulders		Bellies
	1	2	1	2	2
Grease**	7.4	5.2	7.2	5.7	5.3
Insoluble Ash	0.1	0.1	0.4	0.2	0.1
Water Solubles	28.1	28.2	29.7	32.0	28.4
Hide Substance	38.6	41.3	37.7	37.7	37.5
Combined Tannin	25.7	25.3	25.0	24.5	28.7
Degree of Tannage	66.6	61.2	66.2	65.1	76.6
Uncombined Tannin	9.7	9.7	11.1	10.9	9.3
Soluble Nontans	18.4	18.5	18.6	21.1	19.1
Total Ash	5.5	5.0	4.8	6.9	6.8
Glucose	6.4	6.8	7.7	6.8	6.3
Epsom Salt	7.5	5.8	5.7	8.7	6.2
pH	3.5	3.5	3.1	3.5	3.3

*Each of the 2 lots was sampled separately, except for the bellies, where lot No. 1 was not sampled.

**Petroleum ether extract.

No difficulties were encountered in replacing standard U.S. specification material for welting leather, counters and heel bases with canaigre leather.

4. Field test arrangements

Altogether 216 pairs of shoes were issued to troops on garrison duty, 193 pairs at Fort Bragg, N.C. and 23 pairs at Fort Lee, Va. The results of the testing at these two sites were treated together in the final evaluation. (13) The shoes were inspected after 2 and 8 months of wear and at the conclusion of the test, which represented 14 months of wear. Whenever a test subject dropped out, he was replaced, if possible, unless one of his test shoes had become unserviceable. Outsoles that had worn through were replaced at least once and sometimes twice during the test period. For various reasons, however, 11% of the shoes issued could not be recovered at the close of the test. In order to obtain comments on comfort and water resistance, participants were interviewed at the time of issue and withdrawal, as well as at the two intermediate inspection dates. Inspection was mainly concerned with shape stability and with curling or cracking of outsoles and insoles. Wearing qualities were estimated by counting the outsole failures and also by measuring the loss in thickness of leather during wear.

PART II: RESULTS AND DISCUSSION OF FIELD TEST

1. Subjective findings

a. Shape stability

Most of the test subjects rated the standard shoes and the test shoes constructed with canaigre-tanned components the same when asked "whether or not they keep their shape in the sole and back of the shoe," and even more when asked "how they fit around the heels." In the few instances where loss of stability in the counter area was reported by the test subjects and confirmed by visual inspection, very little or no discomfort was felt.

b. Outsole curling and cracking

In judging the appearance of outsoles, distinctions were made by inspection personnel between slight, moderate and severe curling and cracking. All shoes were examined for these defects after 2, 8 and 14 months. However, since many shoes wore through and had to be withdrawn, the number of soles available for examination was less than half after 8 months and still fewer at the end of the test (14 months). These conditions are reflected in Table V which summarizes the results. Since "severe" curling and cracking was rare, the table represents all 3 degrees of curling and cracking - slight, moderate, severe - as established in the field trial.

As can be seen from Table V, signs of curling appeared on slightly less than half of the outsoles after 2 months of wear and on most of the rest after 8 months. At this inspection date when a considerable number of original outsoles were still being worn, the cases of severe curling numbered only 9, all of these on canaigre-tanned leather. Therefore, it seems that this leather had more of a tendency to curling than standard leather. But curling is not a very serious fault and when known to occur, can be easily corrected in the manufacture of the leather.

TABLE V: CURLING AND CRACKING OF CANAIGRE-TANNED AND STANDARD OUTSOLES AT 2, 8 AND 14 MONTHS OF WEAR

(In number of outsoles)

Total Number			Curling			Cracking		
(2)	(8)	(14)	(2)	(8)	(14)	(2)	(8)	(14)
			Standard					
216	106	64	93	99	41	2	8	3
			Canaigre, untreated					
108	43	26	52	40	19	7	20	8
			Canaigre, oil-treated					
108	63	38	50	61	35	4	13	3

Cracking of outsoles, on the other hand, is a grave defect, and its incidence in a wear test should be very low. As Table V shows, standard leather did not crack very often. Cracking of canaigre leather was more frequent, especially after 8 months. Most of the cracking was slight. Only 20 cases of cracked outsoles were graded "moderate to severe." Of these, 1 was on standard outsoles, 7 on oil-treated canaigre soles and 12 on untreated canaigre soles. From these figures and from the table, it appears that the oil treatment materially aided in preventing crackiness. However, caution must be exercised in the interpretation of the figures because of the small sample (or, as the statistician says, "population") from which they were taken.

c. Insole deterioration

After 2 and 8 months of wear, the number of insoles showing curling or cracking was very small (less than 10%) and did not show a definite trend traceable to the tannage. During the last

6 months of the test, however, the picture changed very distinctly in favor of the standard tannage, as Table VI shows. These results, however, can be fully explained by the fact that the canaigre-tanned insoles had not been chrome retanned as had the standard insoles. Previous experience has shown (14) that the wearing qualities of insoles can be markedly improved by the presence of chrome. The findings of the evaluation agency, as far as insoles are concerned, merely confirm these earlier observations but have no bearing on the question of substituting canaigre for a standard tannage. None of the insoles showed evidence of piping and guttering.

TABLE VI: CURLING AND CRACKING OF CANAIGRE-TANNED AND STANDARD INSOLES AFTER 14 MONTHS

(In number of insoles)

	Curling		Cracking	
Total Number	Slightly	Moderately to Severely	Slightly	Moderately to Severely
		Standard		
159	76	2	18	1
		Canaigre-tanned		
159	114	11	61	73

2. Objective findings

Two properties of the test shoes were investigated by the evaluation agency on the basis of objective measurements: 1) water resistance of the sole construction and 2) durability of the outsoles.

a. Water resistance

Water absorption was tested under static and dynamic conditions. In the static test new shoes were placed in a container or trough

containing water of a sufficient depth to cover the outsole but not to come over the welt. The shoes were removed from the container at hourly intervals and weighed for moisture pickup. The weights were recorded, and the weighings continued for 6 hours.

After the 6th hourly weighing, the shoes were placed back in the container and remained in the water for another 18 hours, after which they were removed and weighed. The shoes were then returned to the test subjects for normal wear. The weight increases for each shoe were recorded. The same test was performed after 3 months of normal wear. The results obtained after 1, 6 and 24 hours immersion are compiled in Table VII. They show that shoes with canaigre-tanned components are about as water-resistant as standard shoes if their soles are oil-treated and that the beneficial effect of the oil treatment is retained over a period of at least 3 months of wear. Table VII also shows that worn shoes absorb water considerably faster.

TABLE VII: STATIC WATER ABSORPTION TEST: INCREASE IN WEIGHT (%) OF SHOES AFTER 1, 6 AND 24 HOURS IMMERSION

Number of cross-mated outsoles tested		1 hour		6 hours		24 hours	
new	worn*	new	worn*	new	worn*	new	worn*
		Standard					
5	5	1.1	2.2	3.0	4.7	4.4	8.7
		Canaigre, untreated					
2	3	3.4	5.3	6.0	9.0	8.8	16.0
		Canaigre, oil-treated					
3	2	1.2	2.2	3.1	5.1	4.8	12.4

*After 3 months wear

For the dynamic test an area of matted pine needles was thoroughly wetted to provide a soggy walking surface. The test was conducted with the same pairs of shoes used in the static test. Between the static and dynamic tests the shoes were allowed to dry out for one week. For the dynamic test each shoe was weighed before the test subjects began walking over the ground covered with pine needles. Every 20 minutes the shoes were taken off briefly and weighed. Altogether 5 such weighings were recorded. Three of these, after 20, 60 and 100 minutes, were used for computing the weight increase in percent, shown in Table VIII. As in the static test, the shoes with canaigre-tanned components were about as water-resistant as standard shoes. All 3 types of shoes, whether new or worn, picked up about as much water after 1 hour in the dynamic test as after 6 hours in the static test.*

TABLE VIII: DYNAMIC WATER ABSORPTION TEST: INCREASE IN WEIGHT (%) OF SHOES AFTER 20, 60 AND 100 MINUTES

Number of cross-mated outsoles tested		20 minutes		60 minutes		100 minutes	
new	worn*	new	worn*	new	worn*	new	worn*
		Standard					
5	5	2.1	2.0	4.8	4.5	5.8	5.6
		Canaigre, untreated					
2	3	4.3	4.9	7.4	8.6	9.0	9.8
		Canaigre, oil-treated					
3	2	1.7	2.8	4.2	5.0	5.5	6.1

*After 3 months wear

* If this factor of 6 holds true also for 100 minutes of walking, this time would compare with 10 hours in the static test. Whether or not this assumption is correct cannot be proven, since no measurements were taken between 6 and 24 hours.

The weighing of the test shoes also revealed that they lost on the average 2.5% water-soluble matter during the static test. This loss may have somewhat affected the results of the dynamic test, since this test followed the static test. During 3 months of wear the shoes lost, of course, still more weight; when retested, they weighed 6.2% less than new. Much of this loss is probably leather that wore off during wear. Since the weight losses did not seem to depend on the type of tannage or on the oil treatment, they have not been presented in this report.

b. Outsole wear characteristics

The wear resistance of the outsoles was measured in two ways: 1) by counting holes requiring withdrawal from test (Table IX); 2) by comparing outsole thicknesses in the toe, inner ball and outer ball area before wear and at the time of withdrawal because of failure or termination of test (Table X).

The first method of evaluation (Table IX) gives the impression that standard leather soles wore about 3 times better than their canaigre-tanned mates. Moreover, the oil treatment did not seem to upgrade canaigre-tanned soles very much. Only a few more soles were prevented by the oil-treatment from being worn through.

TABLE IX: HOLE COUNT (NUMBER OF SOLES WITH HOLES) OF CANAIGRE-TANNED AND STANDARD OUTSOLES IN FIELD TEST

Cross-mated pair		Cross-mated pair	
Standard	Canaigre, Untreated	Standard	Canaigre, Oil-treated
	Holes		
17	75	24	68
	No Holes		
80	22	71	27

The fact is, of course, that counting failures by the number of holes is a simple but not a very reliable method. First of all, the report of the evaluation agency states that "in some instances when holes occurred between inspections or while the test shoes were unavailable because of the absence of test subjects from the test sites, the subjects, in spite of instructions to the contrary, continued to wear shoes in which an outsole failure had occurred. Consequently, some outsoles received additional wear and loss of leather and in some instances also developed small holes after their mates had failed. This situation developed primarily in cases where the failures occurred first in the experimental outsoles." Secondly, counting holes disregards the fact that abrasion may also have progressed very far in the soles which still appear to be intact; in other words, it must lead to estimates heavily weighted in favor of test material which may be only slightly superior.

The second method of evaluation, by measuring thickness losses during wear, appears to be much more conclusive (Table X). In this method average thickness before wear was obtained on 7 outsoles of each type. Thickness after wear was measured on about 190 pairs of outsoles representing the cross-matched types of tannage in nearly equal proportions. Holes had to be scored as zero, but averages were also influenced by the wide range of thickness values found on soles that had not been worn out. The figures of Table X show that the areas of the inner and outer ball do not differ appreciably in the degree of abrasion and are much more heavily abraded than the toe area. The losses in thickness of the canaigre-tanned outsoles in the 3 areas are on the average only 26% greater than the losses of the standard soles. The oil treatment reduces this loss to 22%, as against 30% for the untreated soles. This improvement, although modest by comparison with previous wear tests with oil-treated soles (15,16), is probably caused by the better water resistance of oil-treated leather. As Tables VII and VIII show, the oil treatment improved the performance of the canaigre-tanned leather in the static and dynamic water absorption tests to such an extent that it equaled that of standard leather.

TABLE X: WEAR TEST: THICKNESS LOSSES OF CANAIGRE-TANNED AND STANDARD OUTSOLES

Area measured	Average Thickness* Before wear	Average Thickness* After wear**	Loss in thickness In percent of: original thickness	Loss in thickness In percent of: standard loss
Standard				
Toe	217	107	51	100
Inner ball	227	69	70	100
Outer ball	224	71	68	100
Canaigre, untreated				
Toe	243	66	73	143
Inner ball	245	33	87	124
Outer ball	242	41	83	122
Canaigre, oil-treated				
Toe	217	75	65	128
Inner ball	222	42	81	116
Outer ball	224	40	82	121

* In 1/1000 inch

**At the thinnest point - holes scoring zero

The principal advantages of presenting the results in the form shown in Table X is that they reflect much better than Table IX the actual wear resistance of canaigre-tanned versus standard leather. The frequency of holes (Table IX) suggested that the standard was 3 to 4 times as good as the canaigre-tanned, while on the basis of thickness losses (Table X), the standard soles were only about 25% better.

The results of Table X, more clearly than any others, supply the answer which this field test was supposed to furnish. Additional data, whether collected through interviews or in side experiments conducted on a small scale, appear irrelevant to the principal task, namely, to test the wear resistance of two types of leather. Such data have been included in this report - at the risk of diverting the attention of the reader - only to discourage future experimentation along similar lines.

Conclusions

In the light of the field test evaluated in this report, it is reasonable to assume that canaigre extract is an acceptable domestic substitute for imported vegetable tanning materials. This important conclusion rests on the following considerations:

1) Contrary to tannery practice, canaigre extract was used by itself for tanning. Ordinarily, blends of 2 or more extracts are used, a practice which improves leather quality, including wear characteristics.

2) The field test was conducted with leather produced in the first large-scale trial with canaigre extract, that is, before the tannage on this scale could be studied and the quality of the production could be improved through experience.

3) Canaigre-tanned soles would greatly benefit from recent advances in the impregnation of leather with synthetic rubber resin mixtures. Since the service life of leather treated in this manner is improved by about 50%, differences between tannages that existed before impregnation may be largely eliminated.

Given an opportunity, the leather manufacturing industry would, therefore, be in an excellent position to improve the canaigre tannage so that it would compare favorably with present processes which represent the best efforts of many years of painstaking development work. One can hardly expect the same result on the first trial with a new and unfamiliar material.

The outcome of the field test, in other words, confirms the potential value of canaigre as a tanning agent and should be taken as supporting any further action contemplated on making canaigre extract available to the tanning industry. Such recommendation, however, does not lie within the scope of the present investigation.

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